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AMENDMENT 3
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Information technology — MPEG audio technologies —

Part 2: Spatial Audio Object Coding (SAOC)

AMENDMENT 3: Dialogue enhancement

Technologies de l'information — Technologies audio MPEG —
Partie 2: Codage d'objet audio spatial (SAOC)
AMENDEMENT 3: Rehaussement des dialogues

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The committee responsible for this document is ISO/IEC JTC 1, *Information technology*, Subcommittee SC 29, *Coding of audio, picture, multimedia and hypermedia information*.

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Information technology — MPEG audio technologies —

Part 2:
Spatial Audio Object Coding (SAOC)

AMENDMENT 3: Dialogue enhancement

Add Clause 12, Spatial Audio Object Coding — Dialogue Enhancement (SAOC-DE):

12 Spatial Audio Object Coding — Dialogue Enhancement

12.1 Introduction

This Clause specifies the SAOC Dialogue Enhancement (SAOC-DE) profile. The SAOC-DE decoder processing and bitstream syntax are defined according Clauses 1 to 9 with the following modifications.

— **Basic structure of the SAOC transcoder/decoder**

Add in "Table 2 — Operation modes of the SAOC" the following text:

Table 2 — Operation modes of the SAOC

Output signal configuration	# of output channels	# of input channels	SAOC module mode	SAOC module output	MPS decoder required
mono/stereo/binaural/ 3-channel configuration	1, 2 or 3	1, 2 or 3	Decoder	PCM output	No
multi-channel configuration	> 2	1 or 2	Transcoder	MPS bitstream, downmix signal	Yes

— **SAOC Profiles and Levels**

Add in "Table 4 — SAOC Profiles and Levels" the following text:

Table 4 — SAOC Profiles and Levels

Profiles	Baseline profile				DE profile		LD profile		
Levels	1	2	3	4	1	2	1	2	3
Hybrid QMF bank	X	X	X	X	X	X	-	-	-
LD-QMF bank	-	-	-	-	-	-	X	X	X
Max number of residual channels	0	2	4	4	0	3	-	-	-
Max sampling rate [kHz]	48	48	48	96	48	48	48	48	48
Max number of objects	8	16	32	32	6	6	8	32	32
Max number of downmix channels	2	2	2	2	3	3	1	2	2
Min number of required output channels*)	2	2	2	2	1	1	2	2	5
Use of decorrelator	yes	yes	yes	yes	no	no	yes	yes	yes
PCU HQ decoder	12.2	20.4	33.9	67.8	12.4	22.1	8.4	20.7	39.3**)
PCU LP decoder	6.6	12.2	23.0	46.0	11.4	21.0	N/A	N/A	N/A

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Table 4 *(continued)*

Profiles	Baseline profile				DE profile		LD profile		
PCU addition for transcoding	1.1	1.1	1.1	2.3	N/A	N/A	0.7	1.1	N/A
PCU reduction for integrated transcoding	-6.8	-6.8	-6.8	-6.8	N/A	N/A	-3.6	-6.5	N/A
RCU HQ decoder	5.7	9.8	13.5	17.5	6.3	12.3	3.6	4.2	17.9***)
RCU LP decoder	4.8	5.4	5.7	10.3	7.3	7.9	N/A	N/A	N/A
RCU reduction for integrated transcoding	-1.3	-1.3	-1.3	-1.3	N/A	N/A	-0.6	-1.3	N/A

Add below "Table 4 – SAOC Profiles and Levels" the following text:

MPS transcoding support for baseline and LD profile if the number of output channels > 2

Replace below "Table 4 – SAOC Profiles and Levels" the following text:

The SAOC decoder type is defined by the four conditions:

— Profile: baseline profile or LD profile

by

The SAOC decoder type is defined by the four conditions:

— Profile: baseline, LD or DE profile

Replace in "5.5 SAOC Profiles and Levels":

For all profiles and levels the following features are supported:

— Decoding to mono/stereo/binaural output

by

For baseline and low-delay profiles:

— Decoding to mono/stereo/binaural output. Transcoding to 5.1 is supported

For Dialogue enhancement profile:

— Decoding to mono/stereo/3-channel output. No transcoding to 5.1 is supported

— Multi-channel background object (MBO) processing, DCU processing, MCU processing, separation metadata and send effects interface are not supported

— Post-downmix gain processing (PDG) is supported only in combination with post(processing) re-application processing step

— Insert effects interface is supported only if no modification range control (MRC) settings are transported in the bitstream

12.2 Terms and definitions

Add in "4.4 Variables":

N_{FGO} is the number of FGOs.

$\mathbf{D}_{FGO}$ is the downmix sub-matrix for FGOs.

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$\mathbf{D}_{BGO}$ is the downmix sub-matrix for BGOs.

m_{BGO} is the modification gain for BGOs.

m_{FGO} is the modification gain for FGOs.

m_G is the decoder limited modification gain.

m_G^{input} is the input modification gain.

Add in "4.5 Abbreviated terms":

BGO Background Object

FGO Foreground Object

DE Dialogue Enhancement

12.3 Payloads for SAOC-DE

The bitstream syntax of the SAOC-DE is not compatible with the Baseline and Low Delay profiles of SAOC. The following changes are applied for SAOC-DE profile in *"6.1 Payloads for SAOC"*:

Introduction of DE bitstream elements

Replace in "Table 5 — Syntax of SAOCSpecificConfig()":

Table 5 — Syntax of SAOCSpecificConfig()

Syntax	No. of bits	Mnemonic
SAOCSpecificConfig() {		

by

Table 5 — Syntax of SAOCDESpecificConfig()

Syntax	No. of bits	Mnemonic
SAOCDESpecificConfig() {		

Replace in "Table 20 — Syntax of SAOCFrame()":

Table 20 — Syntax of SAOCFrame()

Syntax	No. of bits	Mnemonic
SAOCFrame() {		

by

Table 20 — Syntax of SAOCDEFrame()

Syntax	No. of bits	Mnemonic
SAOCDEFrame() {		

Replace in "Table 21 — SAOCFramingInfo()":

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Table 21 — Syntax of SAOCFramingInfo()

Syntax	No. of bits	Mnemonic
SAOCFramingInfo() {		

by

Table 21 — Syntax of SAOCDEFramingInfo()

Syntax	No. of bits	Mnemonic
SAOCDEFramingInfo() {		

Replace in "Table 20 — Syntax of SAOCFrame()":

Table 20 — Syntax of SAOCFrame()

Syntax	No. of bits	Mnemonic
SAOCFrame() { SAOCFramingInfo();		

by

Table 20 — Syntax of SAOCDEFrame()

Syntax	No. of bits	Mnemonic
SAOCDEFrame() { SAOCDEFramingInfo();		

Introduction of SAOC version bitstream element

Add in "Table 5 — Syntax of SAOCSpecificConfig()":

SAOCDESpecificConfig()		
{		
bsVersion;	**4**	**uimsbf**
if (bsVersion == 0) {		
bsSamplingFrequencyIndex;	**4**	**uimsbf**

Add in "Table 5 — Syntax of SAOCSpecificConfig()":

```
        SAOCExtensionConfig();
    }
}
```

Add in "Table 20 — Syntax of SAOCFrame()":

```
SAOCDEFrame()
{
    if ( bsVersion == 0 ) {
        SAOCDEFramingInfo();
```

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Add in "Table 20 — Syntax of SAOCFrame()":

SAOCExtensionFrame();		
}		
}		

Disabling SAOC Low Delay mode signalization

Remove from "Table 5 — Syntax of SAOCSpecificConfig()":

bsLowDelayMode;	**1**	**uimsbf**

Replace in "Table 5 —Syntax of SAOCSpecificConfig()":

if (bsLowDelayMode == 0) {		
bsFrameLength;	**7**	**uimsbf**
} else {		
bsFrameLength;	**5**	**uimsbf**
}		

by

bsFrameLength;	**7**	**uimsbf**

Replace in "Table 21 — SAOCFramingInfo()":

If (bsLowDelayMode == 0) {		
bsNumParamSets;	**3**	**uimsbf**
} else {		
bsNumParamSets;	**1**	**uimsbf**
}		

by

bsNumParamSets;	**3**	**uimsbf**

Disabling absolute energy information transport

Remove from "Table 5 — Syntax of SAOCSpecificConfig()":

bsTransmitAbsNrg;	**1**	**uimsbf**

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Remove from "Table 20 — Syntax of SAOCFrame()":

```
if ( bsTransmitAbsNrg ) {
    idxNRG = EcDataSaoc(NRG, 0, numBands);
}
```

Modification on object information transport

Replace in "Table 5 — Syntax of SAOCSpecificConfig()":

bsNumObjects;	**5**	**uimsbf**

by

bsNumObjects;	**3**	**uimsbf**
bsNumFGOs;	**3**	**uimsbf**

Modification on downmix channel number signalization

Replace in "Table 5 — Syntax of SAOCSpecificConfig()":

bsNumDmxChannels;	**1**	**uimsbf**

by

bsNumDmxChannels;	**3**	**uimsbf**

Dual mode configuration information transport

Remove from "Table 5 — Syntax of SAOCSpecificConfig()":

if (bsNumDmxChannels == 1) {		
bsTttDualMode;	**1**	**uimsbf**
if (bsTttDualMode) {		
bsTttBandsLow;	**5**	**uimsbf**
bsTttBandsHigh = numBands;		Note 1
} else {		
bsTttBandsLow = numBands;		
}		
}		

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Disabling post downmix gain information transport

Remove from "Table 5 — Syntax of SAOCSpecificConfig()":

bsPdgFlag;	**1**	**uimsbf**

Remove from "Table 20 — Syntax of SAOCFrame()":

```
if ( bsPdgFlag == 1 ) {
    for (i=0; i<bsNumDmxChannels + 1; i++) {
        idxPDG[i] = EcDataSaoc(PDG, i, numBands);                    Note 1
    }
}
```

Modification on downmix information transport

Replace in "Table 20 — Syntax of SAOCFrame()":

```
idxDMG = EcDataSaoc(DMG, 0, bsNumObjects+1);
if ( bsNumDmxChannels == 1 ) {
    idxDCLD = EcDataSaoc(DCLD, 0, bsNumObjects+1);
}
```

by

```
for (i=0; i<bsNumDmxChannels + 1; i++) {
    idxDMG[i] = EcDataSaoc(DMG, 0, bsNumObjects+1);
}
```

Modification range control setting transport

Add in "Table 5 —Syntax of SAOCSpecificConfig()" the following text:

bsOneIOC;	**1**	**uimsbf**
bsDeLimitFlag;	**1**	**uimsbf**
if (bsDeLimitFlag == 1) {		
bsDeLimitFgo;	**4**	**uimsbf**
bsDeLimitBgo;	**4**	**uimsbf**
} else {		
bsDeLimitFgo = 0;		
bsDeLimitBgo = 0;		
}		

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Add in "Table 20 — Syntax of SAOCFrame()" the following text:

idxDMG[i] = EcDataSaoc(DMG, 0, bsNumObjects+1);		
}		
if (bsDeLimitFlag == 1) {		
if (bsIndependencyFlag == 1) {		
bsDeLimitUpdate = 1;		
} else {		
sDeLimitUpdate;	**1**	**uimsbf**
}		
if (bsDeLimitUpdate == 1) {		
bsDeLimitFgo;	**4**	**uimsbf**
bsDeLimitBgo;	**4**	**uimsbf**
}		
}		

Add in "Table 7 — Syntax of SAOCExtensionConfigData(0)":

SAOCExtensionConfigData(0)		
{		
if (bsDeLimitFlag == 1) {		
bsDeLimitFgoEAO;	**4**	**uimsbf**
bsDeLimitBgoEAO;	**4**	**uimsbf**
} else {		
bsDeLimitFgoEAO = 0;		
bsDeLimitBgoEAO = 0;		
}		

Add in "Table 28 — Syntax of SAOCExtensionFrameData(0)":

SAOCExtensionFrameData(0)		
{		
if (bsDeLimitFlag == 1) {		
if (bsIndependencyFlag == 1) {		
bsDeLimitEaoUpdate = 1;		
} else {		
bsDeLimitEaoUpdate;	**1**	**uimsbf**
}		
if (bsDeLimitEaoUpdate == 1) {		
bsDeLimitFgoEAO;	**4**	**uimsbf**
bsDeLimitBgoEAO;	**4**	**uimsbf**
}		
}		

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12.4 Definition of bitstream variables

Add in "6.2 Definition" the following text:

bsVersion Defines the version of the bitstream according to Table AMD3.1.

Table — AMD3.1 — bsVersion

bsVersion	**Meaning**
0	SAOC DE profile, levels 1 and 2
1 ... 15	Reserved

Add in "6.2 Definition" the following text:

bsNumFGOs Defines the number of FGOs according to Table AMD3.2.

Table — AMD3.2 — bsNumFGOs

bsNumFGOs	**Meaning**
0	$N_{FGO} = 1$
1	$N_{FGO} = 2$
2	$N_{FGO} = 3$
3,...,7	N/A

bsNumDmxChannels Defines the number of downmix channels.

Table — AMD3.3 — bsNumDmxChannels

bsNumDmxChannels	**Meaning**
0	mono downmix
1	stereo downmix
2	3-channel downmix
3,...,7	N/A

bsDeLimitFlag Defines whether the values **bsDeLimitFgo**, **bsDeLimitFgoEAO**, **bsDeLimitBgo** and **bsDeLimitBgoEAO** are transmitted in the bitstream.

bsDeLimitUpdate Defines whether the values **bsDeLimitFgo**, **bsDeLimitFgoEAO**, **bsDeLimitBgo** and **bsDeLimitBgoEAO** are updated. More precisely, **bsDeLimitUpdate** == 1 means that the values **bsDeLimitFgo**, **bsDeLimitFgoEAO**, **bsDeLimitBgo** and **bsDeLimitBgoEAO** are updated in the current frame, whereas **bsDeLimitUpdate** == 0 means that the previously transmitted values are kept.

bsDeLimitFgo Defines the value representing the lowest acceptable modification boundary related to the FGO for the modification range control algorithm according to Table AMD3.4.

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Table — AMD3.4 — bsDeLimitFgo, bsDeLimitFgoEAO, bsDeLimitBgo and bsDeLimitBgoEAO parameters quantization table

idx	0	1	2	3	4	5	6	7
DeLimit[idx]	$10^{-7.50}$	$10^{-2.25}$	$10^{-2.00}$	$10^{-1.75}$	$10^{-1.50}$	$10^{-1.25}$	$10^{-1.10}$	$10^{-0.95}$
idx	8	9	10	11	12	13	14	15
DeLimit[idx]	$10^{-0.80}$	$10^{-0.65}$	$10^{-0.50}$	$10^{-0.40}$	$10^{-0.30}$	$10^{-0.20}$	$10^{-0.10}$	1

bsDeLimitFgoEAO Same as **bsDeLimitFgo** but for application only in strict EAO mode.

bsDeLimitBgo Defines the value representing the lowest acceptable modification boundary related to the BGO for the modification range control algorithm according to Table X.

bsDeLimitBgoEAO Same as **bsDeLimitBgo** but for application only in strict EAO mode.

bsDeLimitUpdate Defines whether the values **bsDeLimitFgo** and **bsDeLimitBgo** are updated. More precisely, **bsDeLimitUpdate** == 1 means that the values **bsDeLimitFgo** and **bsDeLimitBgo** are updated in the current frame, whereas **bsDeLimitUpdate** == 0 means that the previously transmitted values are kept.

bsDeLimitEaoUpdate Defines whether the values **bsDeLimitFgoEAO** and **bsDeLimitBgoEAO** are updated. More precisely, **bsDeLimitEaoUpdate** == 1 means that the values **bsDeLimitFgoEAO** and **bsDeLimitBgoEAO** are updated in the current frame, whereas **bsDeLimitEaoUpdate** == 0 means that the previously transmitted values are kept.

Add in "6.2 Definition" the following text:

Table — AMD3.5 — bsPresetMatrixType

bsPresetMatrixType	**Meaning**
0	Mono playback system
1	Stereo playback system
2	5.0 playback system
3	3.0 playback system

12.5 Signals and parameters

Input downmix signal

Add in "7.5.2 Input signal" the following text:

$$\mathbf{X} = \mathbf{x}^{n,k} = \begin{pmatrix} x_0 \\ \dots \\ x_M \end{pmatrix}$$ for SAOC-DE downmix channel configurations,

$$\mathbf{X} = \mathbf{x}^{n,k} = \begin{pmatrix} l_0 \\ r_0 \end{pmatrix}$$ for stereo downmix,

Rendering matrix

Object rendering matrix $\mathbf{M}_{\text{ren}}$ for the SAOC-DE profile can be represented as a function of two gains m_{BGO} (for BGOs) and m_{FGO} (for FGOs) which can be specified by one scalar input value m_{G}.

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Add in "7.5.4 Rendering matrix" the following text:

$$\mathbf{M}_{\text{ren}} = \begin{pmatrix} m_{0,C} & \cdots & m_{N-1,C} \end{pmatrix} \qquad \text{for mono output configuration,}$$

$$\mathbf{M}_{\text{ren}} = \begin{pmatrix} m_{0,0} & \cdots & m_{N-1,0} \\ \cdots & \cdots & \cdots \\ m_{0,M-1} & \cdots & m_{N-1,M-1} \end{pmatrix} \qquad \text{for SAOC-DE output channel configurations,}$$

determined as

$$\mathbf{M}_{\text{ren}} = \begin{pmatrix} m_{BGO}\mathbf{D}_{BGO} & m_{FGO}\mathbf{D}_{FGO} \end{pmatrix},$$

where

$m_{FGO} = m_G$ and $m_{BGO} = 1$, if $m_G \leq 1$,

$m_{FGO} = 1$ and $m_{BGO} = m_G^{-1}$ if $m_G > 1$.

Downmix matrix

Add in "7.5.5 Downmix matrix" the following text:

Here, the dequantized downmix parameters are obtained according to 7.1.2 as

$$DMG_j = \mathbf{D}_{\text{DMG}}(j,l), \qquad DCLD_j = \mathbf{D}_{\text{DCLD}}(j,l).$$

For the SAOC-DE output channel configurations the downmix matrix $\mathbf{D}$ of size $M \times N$ with elements $d_{i,j}$ $(i = 0,...,M-1;\ j = 0,\ldots,N-1)$ is obtained from the DMG parameters as

$$d_{i,j} = 10^{0.05 DMG_{i,j}}.$$

The downmix matrix has the following structure

$$\mathbf{D} = \begin{pmatrix} \mathbf{D}_{BGO} & \mathbf{D}_{FGO} \end{pmatrix}.$$

The matrix $\boldsymbol{D}_{BGO}$ of size $M \times N - N_{FGO}$ corresponds to the background and $\mathbf{D}_{FGO}$ of size $M \times N_{FGO}$ corresponds to the foreground objects.

Here, the dequantized downmix parameters are obtained according to 7.1.2 as

$$DMG_{i,j} = \mathbf{D}_{\text{DMG}}(i,j,l).$$

Post(processing) of downmix

Add in "Signals and parameters" the following text:

7.4.3 Post(processing) downmix compensation

The matrix $\mathbf{W}_{\text{PDG}}$ is obtained from the transmitted PDG parameters as

$$\mathbf{W}_{PDG} = \begin{pmatrix} PDG_1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & PDG_M \end{pmatrix}, \qquad \text{for SAOC-DE profile,}$$

Add in "Signals and parameters" the following text:

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7.4.X Post(processing) re-application

If the post(processed) downmix compensation is applied (**bsPdgFlag** == 1) for the SAOC-DE profile, the following modification should be taken after the SAOC processing

$$\hat{\mathrm{X}}_{\mathrm{post(processed)}} = \mathrm{W}_{PDG}^{-1}\hat{\mathrm{X}},$$

where

$$\mathbf{W}_{PDG}^{-1} = \begin{pmatrix} \frac{1}{\max(PDG_1, \varepsilon)} & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \frac{1}{\max(PDG_M, \varepsilon)} \end{pmatrix}.$$

Replace in "SAOC transcoding/decoding modes" the following figure:

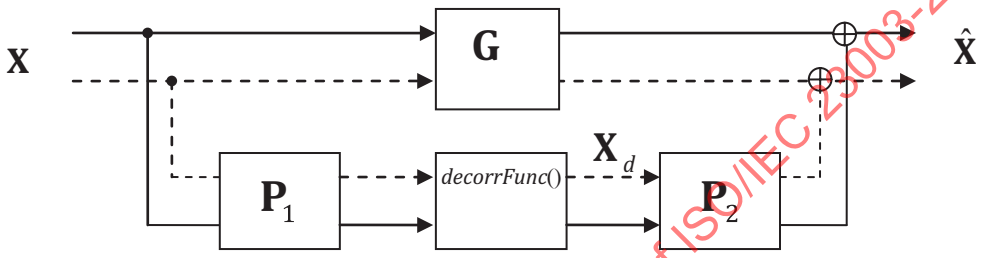

Figure 13 — Basic structure for the SAOC transcoding/decoding modes

by

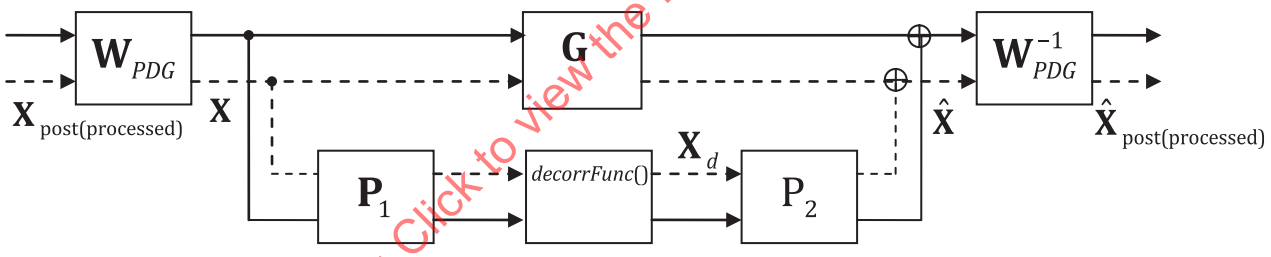

Figure 13 — Basic structure for the SAOC transcoding/decoding modes

12.6 Decoding mode for SAOC-DE

The parametric processing algorithm supporting up to 3-channel downmix configurations is specified as follows.

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Add in "7.7.2 Downmix processor" the following text:

7.7.2.7 SAOC-DE "x-y-y" processing mode

The upmix parameters **G**, $\boldsymbol{P}_1$ and $\boldsymbol{P}_2$ are computed as

$$\mathbf{G} = \mathbf{M}_{\text{ren}}\mathbf{E}\mathbf{D}^{*}\mathbf{J}, \qquad \mathbf{P}_1 = 0,\ \mathbf{P}_2 = 0.$$

where $\mathbf{J} \approx \left(\boldsymbol{D}\boldsymbol{E}\boldsymbol{D}^{*}\right)^{-1}$. The matrix **J** of size $M \times M$ is defined as

$$\mathbf{J} = \mathbf{U}\boldsymbol{\Lambda}^{inv}\mathbf{U}^{*}.$$

Here the singular vector **U** of the matrix product **DED*** is obtained using the following characteristic equation

$$\mathbf{U}\boldsymbol{\Lambda}\mathbf{U}^{*} = \mathbf{D}\mathbf{E}\mathbf{D}^{*}.$$

The regularized inverse $\boldsymbol{\Lambda}^{inv}$ of the diagonal singular value matrix $\boldsymbol{\Lambda}$ is computed as

$$\lambda_{i,j}^{inv} = \begin{cases} \dfrac{1}{\lambda_{i,j}}, & \text{if} \quad i = j \quad \text{and} \quad \lambda_{i,j} \geq T_{reg}^{\Lambda}, \\ 0, & \text{otherwise,} \end{cases}$$

The relative regularization scalar T_{reg}^{Λ} is determined using absolute threshold T_{reg} and maximal value of $\boldsymbol{\Lambda}$ as

$$T_{reg}^{\Lambda} = \max\left(abs\left(\lambda_{i,i}\right)\right)T_{reg}, \qquad T_{reg} = 10^{-2}.$$

The decorrelator signal path is disabled $\boldsymbol{X}_{\text{d}} = 0$.

12.7 EAO processing for SAOC-DE

The SAOC architecture supporting EAO for up to 3-channel downmix configurations is specified as follows.

Add (after "7.8 EAO processing") the following text:

7.X EAO processing for SAOC-DE processing modes

The final output $\hat{\mathbf{X}}$ of the SAOC decoder is defined from the downmix signal **X** using the SAOC parametric information, residual signal $\mathbf{X}_{res}$ and rendering control variables m_{BGO}, m_{FGO} as

$$\hat{\mathbf{X}} = m_{BGO}\mathbf{X} + (m_{FGO} - m_{BGO})\mathbf{D}_{FGO}\left(\mathbf{R}_{eao}\mathbf{E}\mathbf{D}^{*}\mathbf{J}\mathbf{X} + \mathbf{X}_{res}\right).$$

The term $\mathbf{X}_{res}$ of size N_{EAO} incorporates residual signals **res** for EAOs from SAOC bitsream.

The matrix $\mathbf{R}_{eao}$ is defined as $\mathbf{R}_{eao} = \begin{pmatrix}\mathbf{O} & \mathbf{I}\end{pmatrix}$, where the elements of sub-matrix **O** of size $N_{EAO} \times N - N_{EAO}$ is defined as $O_{i.j} = 0$, and sub-matrix **I** of size $N_{EAO} \times N_{EAO}$ is defined as $I_{i.j} = 0$, if $i \neq j$ and $I_{i.j} = 1$, if $i = j$.

12.8 Modification range control for SAOC-DE

The output modification range control for SAOC-DE is specified as follows.

Add (after "7.9 DCU processing") the following text:

7. Modification range control for SAOC-DE processing modes

The modification scalar m_G is obtained from decoder input parameter m_G^{input} using the limitation thresholds $m_{DeLimitFgo}$ and $m_{DeLimitBgo}$ for BGO and FGO as

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